Net Energy Metering Cost-Benefit Study

Phase 1 Scope and Method

October 16, 2012

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1 Background

The CPUC has contracted with Energy and Environmental Economics (E3) to provide an evaluation of the costs and benefits of the Net Energy Metering (NEM) program. This study fulfills the requirements of Assembly Bill 2514 (Bradford, 2012) and Commission Decision (D.) 12-05-036, which requires a study on the costs and benefits of NEM by October 1, 2013. This study will also serve as an update to the CPUC's 2010 NEM Cost Effectiveness Evaluation (2010 NEM Study).

NEM is an electricity tariff that facilitates the deployment of on-site distributed generation (DG) primarily used to offset load. Under NEM tariffs, customers receive a bill credit based on the full retail rate for any excess generation that is exported back to the grid - including generation, transmission, and distribution rate components. In periods when the bill is negative (because the value of the energy produced by the DG facility exceeds the value of the energy consumed on site), the negative balance is carried forward up to one year. Eligible customer generators who produce electricity in excess of on-site load over a 12-month period may elect to receive net surplus compensation, or apply the net surplus electricity as a credit toward future consumption.

The NEM study will be completed in two phases:

Phase 1: Net energy metering ratepayer impact. Following the DG cost-benefit methodology adopted in D. 09-08-026, the first phase of this project will be to calculate the ratepayer impacts of NEM for all participating technologies (solar, wind, fuel cell, microturbine, etc.) using the best available data and information. The analysis will be performed at two penetration levels: The capacity needed to reach the solar photovoltaic goals of CSI and the net metering cap as defined by D. 12-05-036.

Phase 2: White paper on NEM alternatives. In a separate white paper, the second phase of the study will be to compare alternatives to NEM using a framework that highlights the balance between the financial proposition for customers to install renewable DG and the overall impact to ratepayers.

1.1 Proposed methodology for NEM Study – Phase 1

The methodology is similar to the 2010 NEM study, but makes the following substantive changes:

+ The dataset will be expanded to include all NEM customers through December 31, 2011. Since a significant amount of actual interval data has been made available since the 2010 evaluation, the quality of the underlying dataset has been improved. Much of the dataset is confidential (billing records, PV output, AMI data). However, summarized data in a single spreadsheet tool will be made publicly available, including (a) non-confidential characterization of NEM customer consumption / production, (b) retail rate calculation, (c) forecast of impacts.

+ The study will evaluate exported energy delivered to the grid and compensated through NEM and the entire generation output of the NEM generator, consistent with AB 2514.
+ The study will be performed at multiple NEM penetration scenarios, including at a minimum the capacity needed to reach the solar PV goals of CSI and the net energy metering cap as defined by D. 12-05-036.
+ The avoided cost estimates will be updated to reflect methodology changes implemented by the CPUC, and updated market price data and information.
+ The retail rates of NEM customers will be updated to reflect current rates, as will the estimate of future retail rate escalation.
+ The study will disaggregate results by utility, customer class, and household income groups within the residential class, Per D. 12-05-036. For the income distribution of residential NEM participants, results shall be grouped by census block.

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2 NEM Cost-Benefit Study

Our evaluation is limited to the effect of NEM on ratepayers; results of the study will not speak to the overall societal value of the renewable DG under NEM, nor will they establish the wisdom or value of policies that stimulate or incentivize renewable DG.

Specifically, the study will compare the following ratepayer costs and benefits[1]:

- Ratepayer costs
  - Bill reductions resulting from NEM mechanism
  - Incremental billing and admin costs for NEM
  - Interconnection costs not paid by the customer
  - System integration costs
- Ratepayer benefits
  - Utility avoided costs of otherwise supplying energy to meet the load

[1] These costs and benefits are consistent with the methodology for calculating the Ratepayer Impact Measure (RIM) test, as defined in the California Standard Practice Manual for economic analysis of demand-side programs and projects: *http://www.energy.ca.gov/greenbuilding/documents/background/07-J_CPUC_STANDARD_PRACTICE_MANUAL.PDF*. This methodology was adopted for evaluation of distributed generation in CPUC D.09-08-026.

The 2010 NEM Study, also completed by E3, was similar in scope. Once complete, the ratepayer impact calculated in the present report can be directly compared to the results of the 2010 study to suggest trends over time.

2.1 Export Only versus All NEM Generation

In evaluating costs and benefits of NEM, AB 2514 directs the Commission to "consider all electricity generated by renewable electric generating systems, including the electricity used onsite to reduce a customer's consumption of electricity that otherwise would be supplied through the electrical grid, as well as the electrical output that is being fed back to the electrical grid."[2]

An exact measure of the effect of NEM on ratepayers would compare the state of the world with NEM to that without NEM, and calculate the ratepayer costs under both. The state of the world with NEM is the world we live in, and can be calculated with actual measured data. The state of the world *in the absence of NEM*, however, is a counter-factual condition that is not completely knowable. It's not certain exactly how much renewable DG would be installed in California if there were no NEM, nor precisely how customers might choose to size DG they would install or perhaps to change their electricity usage to better align with renewable DG output. At best, we can make educated estimates of customer behavior in the absence of NEM.

[2] Assembly Bill 2514 Net Energy Metering, approved by the Governor and filed September 27, 2012. http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201120120AB2514

Because it is not possible to know for certain how much DG would have been installed in the absence of NEM, this study will consider and present two "bookends" to represent the possible range: (1) consideration of export energy only (NEM-Export), and (2) consideration of all generation (NEM-Generation), both export and direct offset, which satisfies the requirement of AB 2514 to "consider all electricity generated…".

2.2 Disaggregation of Results by Customer Type and Public Purpose Program Effects

AB 2514 further requires that the study "disaggregate the results by utility, customer class, and household income groups within the residential class" and that the study "determine the extent to which each class of ratepayers and each region of the state receiving service under the net energy metering program is paying the full cost of the services provided to them by electrical corporations, and the extent to which those customers pay their share of the costs of public purpose programs."

We will disaggregate results by utility and customer class and estimate the effects of NEM on residential customers of various income strata. The study will also consider the extent to which customers pay the full cost of services provided and the effect of NEM on collection of public purpose program charges.

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3 Methodology

Our calculation of costs and benefits involves three key steps, described in more detail below:

- Development of hourly load and output profiles
- Bill calculation
- Avoided Cost calculation

3.1 Development of Hourly Load and Output Profiles

In the 2010 evaluation, we used limited available data to develop representative “bins” of customers. Each bin contained customers that were similar or identical with regard to utility, climate zone, rate schedule, level of customer load, size of renewable generator, and ratio of generator output to load. In all there were more than 1,200 bins, which represented “typical” load and output profiles given the characteristics delineated above.

For this study, we have been able to obtain somewhat more detailed data. This data will allow us to develop individual load and generation profiles for the majority of NEM customers.

3.1.1 GENERATION PROFILES

We have metered output profiles for a significant minority of NEM generators (several thousand). For the remainder, we will use an in-house simulation tool to develop output profiles, based on generator characteristics (type, size, etc.) which are available for the vast majority of NEM accounts.

3.1.2 LOAD PROFILES

We have hourly or sub-hourly metered load profiles from utility load research data. These load profiles will be sized to customers based on customer characteristics such as total load, location, rate schedule, etc. In addition, we have metered hourly bi-directional *net* load for several thousand customers. When combined with DG output profiles, these bi-directional net load profiles can provide additional gross load profiles that can be sized to similar customers.

Combining the generation and load profiles on an individual customer basis provides us with all the information needed to calculate the bill effects of NEM and the avoided costs. This is true whether we evaluate just the hours of export to the grid or all generation including direct offset of consumption (as noted above, this study will include both).

As mentioned above, we will be able to develop hourly load and generation profiles for the majority of, but not all, customers. For the remaining customers, we will make some estimate of NEM costs based on extending the data we do have to represent those customers where data is lacking. The precise method for this is to-be-determined, but may involve binning as used in the 2010 NEM evaluation.

3.2 Bill Calculation

We have developed an Excel-based bill calculator. From the 8,760 load profiles, we will develop billing determinants necessary to calculate bills for each of the major rate schedules.

To calculate the bill effects for the NEM-Generation scenario (both export and direct offset), we will compare a bill that would occur under the gross load shape without DG to a bill that would occur under NEM (from the actual billing records). The difference between the two bills is the reduction in billing revenue from NEM. In the NEM-Generation scenario we will also calculate the amount of public purpose charges that are avoided through the direct load offset.[3] This value is already part of the bill differential, but we will break it out separately for informational purposes, and in compliance with AB 2514.

To calculate the bill effects in the NEM-Export scenario, we will compare the bill that occurs under NEM (from the actual billing records) to the bill that would occur if the meter were not allowed to spin backward; that is, if the same amount of generation were to occur, but all exported energy were given to the grid without compensation. In the NEM-Export case we will also compute standby charges. Inasmuch as the NEM statute explicitly forgives customers' standby charge obligations, in the absence of NEM customers would potentially be obligated to pay standby costs for the generation that displaces load, since in the case of generator failure the utility would provide that level of energy. We

[3] AB 2514 requires the NEB benefit-cost study to identify "the extent to which [NEM] customers pay their share of the costs of public purpose programs." (Section 1(a)).

will also do a sensitivity to our base case results that assumes standby charges and departing load charges would be exempt in the absence of NEM, as delineated in the sensitivities section below.

3.3 Avoided Cost Calculation

The E3 avoided cost methodology was first adopted for evaluation of energy efficiency programs in CPUC Decision (D.)05-04-024. Subsequently, the use of the E3 avoided cost methodology has been expanded to include other demand-side programs, such as demand response. The CPUC adopted the E3 avoided cost methodology, with some modifications, for use in evaluating distributed generation in D.09-08-026.

Under this methodology, avoided costs are time- and location-specific, calculated for each hour of the year. Avoided costs include the following components:

Table 1: Components of electricity avoided cost

Component	Description
Generation Energy	Estimate of hourly wholesale value of energy adjusted for losses between the point of the wholesale transaction and the point of delivery
System Capacity	The costs of building new generation capacity to meet system peak loads
Ancillary Services	The marginal costs of providing system operations and reserves for electricity grid reliability
T&D Capacity	The costs of expanding transmission and distribution capacity to meet peak loads
Environment	The cost of carbon dioxide emissions associated with the marginal generating resource

Component	Description
Line Losses	The loss in energy from transmission and distribution across distance
Avoided RPS	The cost of purchasing renewable resources to meet an RPS portfolio that is a percentage of total retail sales

The hourly granularity of the avoided costs is obtained by shaping forecasts of the average value of each component with historical day-ahead and real-time energy prices and actual system loads reported by CAISO's MRTU system; Table 2 summarizes the methodology applied to each component to develop this level of granularity.

Table 2: Summary of methodology for electricity avoided cost component forecasts

Component	Basis of Annual Forecast	Basis of Hourly Shape
Generation Energy	Market forwards that transition to the annual average market price needed to cover the fixed and operating costs of a new CCGT, less net revenue from day-ahead energy, ancillary service, and capacity markets.	Historical hourly day-ahead market price shapes from MRTU OASIS
System Capacity	Fixed costs of a new simple-cycle combustion turbine, less net revenue from real-time energy and ancillary service markets	Hourly allocation factors calculated as a proxy for LOLP based on CAISO hourly system loads
Ancillary Services	Scales with the value of energy	Directly linked with market forecast for energy
T&D Capacity	Survey of utility marginal transmission and distribution capacity values from general rate cases and utility project forecasts.	Hourly allocation factors calculated using weather data as a proxy for distribution loads.

Component	Basis of Annual Forecast	Basis of Hourly Shape
Environment (CO2 reduction)	Implied cost of CO2 in the forward electricity markets.	Directly linked with energy shape through implied market heat rate with bounds on the maximum and minimum hourly value
Environment (criteria emissions)	Capitalized cost of procuring emissions permits (NOx, PM10)	Linked to the generation capacity value
Avoided Renewable Purchases	Cost of a marginal renewable resource less the energy and capacity value associated with that resource	Flat across all hours

3.4 Sensitivities

We will conduct the sensitivities described in Table 3. Sensitivity testing will apply primarily to the 2011 results (see Study Results section below).

Table 3: NEM Benefit-Cost Sensitivities

Sensitivity	Description
T&D Avoided Costs	There is disagreement as to whether utilities can really avoid T&D investment as a result of DG. The sensitivity case will calculate results without T&D avoided capacity value.
Natural Gas Prices	Currently, natural gas forward projections are historically low. We will test a higher alternative natural gas price forecast as a sensitivity in our forward-looking analyses.
Billing and Administration	PG&E NEM billing costs remain high relative to the other utilities. We will test alternate billing costs under the assumption that these processes will cost less over time.
Interconnection	Only limited interconnection cost data on non-reimbursed ratepayer costs was available. We will test a range.
Standby Charges	We will calculate results in a sensitivity analysis under the assumption that standby charges and departing load charges would not be assessed in the absence of NEM.
CO2 Price	We will calculate a low and a high sensitivity with the CO2 price at the CO2 allowance price floor and ceiling.

Sensitivity	Description
Load/Resource Balance Year	We will evaluate a sensitivity analysis whereby NEM generation receives the full generation capacity throughout the study horizon rather than a future resource balance year.

3.5 Study Results

We will produce the following results:

- Estimated net ratepayer cost in 2011 for all NEM generation installed through 2011.
- Lifecycle net ratepayer cost for all NEM generation installed through 2011, with sensitivity testing.
    - Breakdown of lifecycle results into groups of like customers, household income groups, utilities, climate zones, etc.
- Forecast of net ratepayer cost at full CSI program subscription and at the 5% NEM cap.
- The income distribution of residential NEM participants, grouped by census block.
- Non-confidential dataset representing NEM customer size and generation data aggregated into 'bins'.

Results described above will be calculated for both the "export only" and "all NEM generation" scenarios.

In addition, we will produce a public calculation tool, populated with the non-confidential billing and avoided cost data that will allow stakeholders to follow the calculations and review the methodology and results.

4 Prior Comments on NEM Methodology

Following the 2010 NEM Study, other researchers and organizations published studies on methodologies for evaluating NEM benefits and costs, sometimes with direct comments on or critiques of the 2010 evaluation. We have taken these comments into consideration and, in some cases, our updated methodology is consistent with observers' suggestions. In other cases, we believe our methodology is valid without revision.

Below, we provide a brief summary of key comments and the consulting team response. This summary is intended to facilitate discussion at the stakeholder workshop on October 22, 2012, by providing a starting point for further discussion.

4.1 Evaluation of energy used onsite

The Interstate Renewable Energy Council (IREC) notes that E3's 2010 evaluation

> …assumes that without NEM in place to support customer-generators, customer-generators would have installed the same amount and type of generation, would not have changed their

> consumption patterns to make better use of their renewable energy investments, and, finally, that excess generation would be delivered to utilities for minimal compensation. This is not a likely outcome.[4]

IREC goes on to assert that customers likely would have installed less generation and would likely also change their energy use patterns or install batteries to directly offset more load.

> **Response:** It is true that the prior study was limited only to export energy and assumed installed generation and usage patterns would have been the same in the absence of NEM. In this study, we will "bookend" possible customer behavior by evaluating (a) only the export energy, and (b) all energy produced by the generator. We do not intend to estimate how customers might have changed their energy use patterns were there no NEM, as any such estimation would be highly speculative.

On the same topic, Crossborder Energy asserts that "It is critical to recognize that NEM only impacts other utility ratepayers in the… 'power export' state, as this is the only state in which the customer's generation actually touches the grid."[5] According to this logic, only the energy export should be considered when calculating the lost revenue from NEM.

[4] Jason B. Keyes and Joseph F. Wiedman, Interstate Renewable Energy Council, *A Generalized Approach to Assessing the Rate Impacts of Net Energy Metering*, January 2012, pp.12-13.
[5] R. Thomas Beach and Patrick G McGuire, Crossborder Energy. *Re-evaluating the Cost-Effectiveness of Net Energy Metering in California*. January 9, 2012, p.4.

Response: A generator that only offsets load and never exports may nevertheless affect other ratepayers. If the customer's bills are reduced by the direct offset, and some of those revenues were recovering fixed costs associated with serving the customer that do not go away (such as service connection), then those fixed costs are no longer recovered from the customer and will now need to be recovered from other ratepayers.

Further, as IREC notes, the same level of generation is unlikely to be installed in the absence of NEM. As noted above, we address these concerns in our study by calculating the "bookends" described above.

4.2 Retail rate assumptions

IREC also notes that the E3 methodology calculates costs based on existing retail rates, which were very high for residential customers due to the tiered rate structure. In general, rates in California are higher than many other places, which will make the cost of NEM appear higher from the ratepayer perspective.[6]

Response: It is true that the ratepayer costs of NEM are directly tied to the rates and the rate structure, and that if rates were lower, the lost revenues from NEM would be lower. Nevertheless, this remains the correct way to measure the impact of NEM on ratepayers. Rate changes that have been implemented since the 2010 NEM study have reduced the highest residential tiers and will dampen this effect in the current study.

[6] IREC., p.13.

Crossborder Energy notes that in the 2010 study, "E3 calculated the 20-year levelized cost shift from NEM assuming that retail rates would escalate at 4.5% per year…well above historical trends."[7]

> **Response:** Historical rate escalation may not be the best guide in the current policy environment. E3 will use the best available retail rate forecast from the CPUC Long-Term Procurement Planning (LTPP) proceeding.

4.3 Standby charges

IREC notes: "Depending on how standby charge tariffs are actually implemented by a particular utility, calculating the potential lost revenues from a standby charge exemption would double count T&D charges."[8]

> **Response:** Inasmuch as the NEM statute forgives NEM customers from paying standby charges that otherwise might apply, the loss of standby revenue is a potential cost of NEM. When calculated correctly, inclusion of loss standby revenue does not result in double counting.

[7] Crossborder, p.9.
[8] IREC, pp.14-15

4.4 Generation capacity valuation method

IREC further asserts that since E3 found, in the 2010 NEM Study, that utilities had little need for capacity until 2015, E3 undervalued the generation capacity provided by NEM generation.[9]

Along a similar line, IREC asserts that "utilities' long-term resource acquisition plans rely on load forecasts based on historical loads that include customer-sited generation and anticipated future customer-sited generation."[10] This is similar to Crossborder Energy's comment that a future load-resource balance year should not be used because "E3's determination…assumes the addition of large amounts of preferred renewable resources (from both the RPS and the CSI)…[and]…these include the resources we are trying to value."[11]

Finally, IREC also notes that E3's "valuation of the capacity benefit of NEM solar generation is considerably lower than the likely valuation of capacity for solar energy purchased by California utilities under long-term contracts,"[12] which use MPR, which is based on total cost of generation.

> **Response:** It is our position that that the capacity value of distributed resources including EE, DR, and NEM generation, should be linked to the capacity need. The avoided costs are based on not having to build something that we would otherwise have had to build. That said, we agree that we do not want to assume we get the load reduction from

[9] IREC, pp.13-14.
[10] IREC, p.14.
[11] Crossborder, p.10.
[12] IREC, p14.

NEM generation before we calculate the value of that load reduction. Therefore, we propose a similar approach to that taken in the energy efficiency proceeding which is to use the load and resource projection without NEM generation to determine the resource balance year in the base case. The current resource balance year without energy efficiency is 2017 based on the most recent completed LTPP. With energy efficiency, and without NEM generation, the resource balance year is beyond 2020. We will discuss the data sources and approach at the workshop.

To test the importance of the load-resource balance year assumption, the 2010 study performed a sensitivity test where load and resources were assumed to be in balance immediately, and we will do so again in this study. In the 2010 study, we found this change made only a small difference to the results.

Regarding MPR, it is the TOD factors that create the significant difference in capacity value and it is not exactly clear how the TOD factors have been developed. The E3 approach to capacity valuation for avoided costs has been adopted by the CPUC and used in numerous demand-side and distributed generation assessments.

4.5 Reactive power and voltage support benefits

IREC notes that the 2010 study does not consider reactive power and voltage support, but that new technology and revised standards will allow such benefits: "While current utility infrastructure does not enable utilities' use of these functions, the implementation of smart grid with associated communications and controls enhancements offers the strong potential to turn this presently deemed cost into a future benefit."[13]

> **Response**: Increasing the value of future NEM generation through provision of reactive power and voltage support is an important research area. In this area, NEM generation can potentially benefit the distribution feeder by (1) reducing losses (2) increase the end of the line voltage and (3) improving power quality with smart inverters. The first of these is already being considered in the study.
>
> Boosting feeder voltage could provide benefits to the extent it is integrated into distribution planning and operations. However, it can also cause costs by changing the voltage profiles of existing feeders which may require design modifications, or operation of transformer tap-changers more frequently. We anticipate future studies to investigate these costs and benefits in more depth. Currently, we do not have a solid foundation to value the costs and benefits of voltage changes on the feeders.

The final category, improving power quality, would require new smart inverter equipment and controls that can adjust reactive power output that are not currently allowed in the interconnection rules. Our expectation is that increased power quality will not result in significant utility cost savings because power quality is not currently an issue on

[13] *Ibid.*, p.14.

most distribution circuits with NEM generation. Smart inverters will generally help mitigate power quality problems stemming from the variable power production of distributed generation. This would not be a monetized benefit, but it would make achievement of higher penetrations of NEM generation possible.

4.6 Natural gas hedging

IREC asserts that renewable DG has a significant impact on natural gas prices and that this hedging value should be recognized in the analysis.

Response: It is important to remember that the CPUC's forecast of natural gas prices is derived from NYMEX futures prices of natural gas, not spot prices. Therefore, any hedging premium in the futures market for fixing natural gas prices is already recognized. Also, we have not done a detailed analysis, but the volume of natural gas demand displaced from renewable DG is likely small compared to other uncertainties in natural gas market supply and demand. Therefore, we do not believe there is any systematic industry shift in the natural gas market that we would have to account for in the analysis.

5 Links for Reference

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